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ABSTRACT

This essay reports on the current state of mathematics education in South Africa. It describes visiting schools and universities and reports on the views of various members of South Africa's mathematical community. Exchanges with students during classroom visits are also presented. (MM)

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A Distant Mirror: Mathematics Education in South Africa

Mark Saul

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A Distant Mirror

Mathematics Education in South Africa

Mark Saul

You don't see the problems of the country when you first get off the plane in Cape Town. The airport could be one in southern California, with its modern terminal, busy newsstands, and screaming advertisements. The people could be American, except that they have continental accents and drive on the left.

But a mile down the six-lane freeway you begin to see Africa. Someone has thrown a network of plastic tarps over a stand of trees, like a construction of tent caterpillars. These are the dwellings of newly arrived squatters from the rural East Cape province. Further on you see more permanent structures of wood or corrugated iron. Area lights poke out high above the squalor, and outhouses line the riverbank.

Further still the huts have acquired electric lines and lost their outhouses. Some, built by the government, are made of concrete. Under apartheid, their occupants had no legal right to live where they could get work, and squatters' camps, shadow cities to each South African metropolis, sprang up. These are the "townships", of which Soweto is the most famous. Long excluded from the country's economy, their populations are restive and anxious. The new government has the task of making these settlements into livable neighborhoods.

The progression continues. Some houses now have two stories, and cars are parked outside. Bars cover the windows: there are things inside that others covet. Next come the older, more stable, "coloured" neighborhoods. This label was given by the architects of apartheid to the large Cape Town community of mixed race, people who speak English or Afrikaans and who lost much as the structures of separatism were raised. Before 1948, they had constituted a solid lower middle class.

After this drive through history I reached my destination, the suburban home of my host, John Webb. John's family has lived in South Africa for the last century. He got his Ph.D. in mathematics at Cambridge and now teaches at the University of Cape Town. John helps to run a system of national competitions in mathematics, leading to the selection of a team to represent the country in the International Mathematical Olympiad. This system has been quite successful: the Olympiad team has scored higher and higher over the years, and participation in preliminary talent searches has increased steadily. It is December, summer vacation in the southern hemisphere, and I have come to help out in a week-long summer camp to develop the students' competition experience and also to work with teachers from all over this diverse country. (My work was being supported by the Anglo-American Chairman's Fund and the D. G. Murray Trust.)

John's suburban neighborhood resembles San Diego more than it does either Africa or Europe. But a few miles away, the shantytowns are growing, as people arrive on buses to join the cash economy of the city. It is as if the lava from an erupting volcano had hardened into a crust just before it engulfed the neighborhood. But someplace far off, the volcano is still smoldering. How do you cap this eruption?

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Part of the answer walked into John's living room the next day. Theo Mokgatlhe is a fifteen-year-old high school student from the Orange Free State. He had worked his way up in the competitions and been invited to the summer camp.

"First I lived in a township near Johannesburg," Theo explained, "where I started school. Then, when apartheid ended, my mom moved us to Welkom, a small city further to the south. I now go to a private school. We speak Sotho at home." Theo speaks and writes a refined continental English. Because he grew up speaking an African language, he would have been classified under apartheid as "black", not "coloured", and would have had available to him only the most meager of the country's educational resources.

"The trip here took sixteen hours. But it was fun. There were other kids on the bus. One of them told me that the Bronx is the toughest neighborhood in America. You grew up there? I would never have guessed."

The full fury of apartheid was directed at children like Theo. Denied an education, they could not form a professional class, could not threaten the hegemony of the South Africans of European ancestry, could not upset the state of affairs these South Africans had so carefully constructed to insulate themselves against the rest of the continent they lived on. In the new South Africa, Theo will prosper. But will the prosperity he will enjoy spread far enough and quickly enough to forestall the social unrest that the country's dreadful inequities foretell?

If John Webb has his way, it will. Like many far-sighted South Africans, he early saw the untenable nature of apartheid. He waited patiently through the repressive 1970s and 1980s and worked quietly to undermine the system that was taking its toll on the country. People with views such as his forced the integration of local public schools and of the dormitories at the University of Cape Town. Only after the crumbling of apartheid, however, were these efforts appreciated by the outside world. For apartheid reserved one of its subtlest torments for its opponents of European descent. When they traveled abroad, they were often put in the position of representing to foreigners the very system they despised and worked to undermine.

Cape Town enjoys a stunning natural environment. The climate is Mediterranean, and a drive about the city reveals majestic vistas of mountain and sea. But I didn't have long to enjoy the sights, as the camp I had come to work at was held outside of the city, in Stellenbosch. This is a university town across the Cape Flats (a wide plain) from Cape Town, in the center of a wine-growing region. The town is all white stucco, and the language is mostly Afrikaans. It was from this university that many of the leaders of apartheid graduated. Now it strives to serve a more diverse population.

My work with the students was not very different from the work I've done countless times in the U.S. These students were hungry for mathematics and good at it. I gave a talk each afternoon, and they couldn't get enough. Indeed, they devoured one of the talks so quickly that I had to supplement it with the next day's material, then was forced to invent yet another lecture. The work was enjoyable, and the only exotic touch was the students' accent, the way they said "anticlockwise" instead of "counterclockwise" (to describe the way the water drained in the sink), and the cricket bat they gave me as a parting gift.

The rest of the day I worked with black teachers from towns throughout the country. My work with these teachers also had a familiar quality. These were highly motivated volunteers who had come during the first week of their vacation to learn some mathematics.

I was a little concerned that I would pitch my material too high or too low. Also, I would be working in English, a second or third language for most of the teachers. But I quickly found that the level appropriate for these teachers was more or less the same as the level for many American teachers I had worked with. And in fact the same classroom techniques also worked. I went through several modules using games to explore mathematics, and they took to the work quickly.

With one important exception. It seems that they hadn't had much of an idea before this workshop that mathematics was something to "do". Rather, they seemed to look on mathematics as a body of knowledge one rehearsed and performed. They all had good presentation skills. (I was told that their typical class had forty or more students.)

And they could think: with varying degrees of success, they could solve the problems I set them. But somehow the notion that the solving of problems actually was the mathematics did not quite click. Why not?

I met with Wilmot James, vice chancellor of Cape Town University. A tall, soft-spoken man, he described a bit of the experience of his family, classified "coloured" under apartheid. "Things have changed since the rationalization of the educational system. Despite other professional aspirations, my father was sent to a vocational school, studied metalwork, then lectured on this in a college. Education for us usually meant a vocational school. Nonetheless, we all managed to get an education, even under apartheid....We are working towards equity, but more than that, towards instilling values in the next generation." I was suddenly reminded not just of the extraordinary violence used to enforce the inequities of the old regime, but of the extraordinary courage, restraint, and moral commitment of those who

eventually triumphed over that regime. Later, a moving visit to Robben Island, the notorious prison for foes of apartheid, put into perspective the remarkable history of this country.

Back in Stellenbosch my hosts filled in for me the picture of "Bantu" education under apartheid. More than 90 percent of the state's education budget went to "white" education. With three other groups ("coloured", "Asian", and "black") to share the remaining 10 percent and with "black" students constituting the majority of the student population, there simply wasn't much to go around.

In the view of some there is evidence that apartheid could not continue, even for the white population whom it ostensibly benefited. Years after the Bantu Education Act but before the breakdown of the whole system, it became clear that South Africa was suffering from a lack of skilled workers, of programmers and other professionals. And this was not just the result of a brain drain. It was also the result of the starvation of the minds of five-sixths of the population. This shortage was beginning to take its economic toll. Too, the exclusion of so much of the population from the economy deprived the country of an internal market and made the international boycott much more than an inconvenience. So quite apart from the political and moral failure of apartheid, the system contained the seeds of its own destruction. The failure of the educational system was part of the failure of the larger system that spawned it.

John Webb spoke more about the budget. "We talk a lot about introducing computers into the schools. But for schools serving the black population, you must first talk about introducing electricity. The attitude of the apartheid regime towards 'Bantu' education was that these people were going to be drawers of water and hewers of wood [an allusion to a famous use by H. F. Verwoerd of a biblical phrase] and needed little mathematics."

So they got little. What they got, it seems—I was dealing with the successes of this system—was a mastery of mechanical methods, the "syntax" of mathematics, without any insight into what the syntax could express.

For example, I gave the teachers in my class a problem: Find the smallest positive number that leaves a remainder of 3 when divided by 7 and also by 9. (No one gave the answer 3, so this version of the problem was safe.)

One of the students, let's call her Anita, got the answer, so I asked her to explain to the others how she did the problem. Poised and articulate, she came up to the blackboard and said, "I followed the method of Pólya. I read the problem. Then I looked for a way to represent the number. I could use $7x$ and also $9x$." Anita didn't notice that she needed a second variable and that she should have written $7x$ and $9y$.

But no matter. In the midst of her formal explanation, Anita suddenly changed course and gave a good description of how she "really" solved the problem, unrelated to her earlier speech about Pólya and problem solving. She explained that if she subtracted 3 from the number she wanted, she would get a number divisible by 7 and also by 9. The smallest such is 63, so the number we want is 66.

Anita and others clearly understood the problem. They were able to give me the next such number and a bit later to write a general expression for all such numbers. This example was typical. The teachers had clearly learned from Pólya, but had mistaken a formal description of the thought process for the thought process itself.

I ran into this difficulty again and again. One day I gave the teachers a problem involving the game Tic-Tac-Toe. It turned out that they weren't familiar with the usual version of the game, so I had to describe it to them. In the midst of my description they all began to mumble something, which turned out to be the word *mrabaraba*, the name of a game that they all knew and of which my description had reminded them. I quickly withdrew my own explanation and asked them to tell me about their game.

Mrabaraba is a version of the game known in England as "Nine Man Morris", which has been analyzed mathematically in some detail [1]. We played it, then posed several mathematical problems based on the game. On encountering one of these problems, the teachers would often first stare at it, trying to fit it into some category of familiar knowledge. I had to give them some sort of tacit or verbal permission to begin to experiment. When they did start to think, they quickly reached important insights and often solved the problem.

Photographs courtesy of Mark Saul.

Nic Heideman earned his Ph.D. in mathematics at Washington University in Saint Louis. He teaches at Rhodes University, in the East Cape province, and, supported by Old Mutual (an insurance company), he works with the teachers in the Queenstown region, a vast rural area with three hundred high school mathematics teachers who have virtually no other professional support. He came to southern Africa from Holland when he was eleven years old, and he speaks English, Afrikaans, and some Xhosa.

One day we were looking at a map, and Nic described to me where the teachers live. One lives near the border with Lesotho, an independent country surrounded by South Africa. It had been a British protectorate, but never got absorbed into

the old Union of South Africa, and so its population never suffered the experiences of apartheid. But they did, and do, suffer grinding poverty and other effects of underdevelopment. It is a poor and mountainous country, inhabited mostly by Sotho-speaking people.

I mentioned to Nic that one of the teachers, Posetso Sekotlo, was a Sotho speaker and told me that he was sent to Lesotho to finish his schooling when the tightening noose of apartheid denied him a good education in South Africa.

Nic's comment was, "It shows, doesn't it?" And in fact it did. Mr. Sekotlo had no trouble digging into the problems, thought well, and did not have to wait for the extra "boost" that many others needed. He and a few other teachers formed an "advanced" group, to whom I constantly had to feed extra problems.

After class one day Mr. Sekotlo approached me and said, "I learned that if you want to multiply some number, say 25476, by 11, all you have to do is write down 6, add 6+7, write down 3, carry 1...". He described a computational trick for multiplying a number by 11. Essentially, if the number was N, he was adding the numeral for N to the numeral for 10N in a nonstandard way.

Then Mr. Sekotlo asked me, "Why does it work?" I showed him why it worked, and he understood immediately. But in this case the question was more significant than the answer. It is the essence of mathematics to try to understand why a mechanical technique works and not just to practice it. Mr. Sekotlo knew to ask why. He understood this in a way that the others didn't. He had not been educated under apartheid.

This is, I think, an important lesson. The curriculum of skill, without concepts, is a curriculum of oppression, a dead end. It is a lesson we in the United States might well take into our own classrooms.

After school one day I was invited to attend a *braaivleis*, a South African barbecue. While we chatted, Nic Heidemann turned to one of the teachers. "Veronica, do you still remember how to carry objects on your head?"

Veronica Xhantini replied, "Of course" and proceeded to demonstrate. We helped her pick up a pail of water so heavy that I had trouble maneuvering it with two hands and placed it on her head. She proceeded to walk around the campgrounds, balancing the pail without using her hands at all.

"Amazing!" I cried. "How did you learn that?"

Ms. Xhantini answered, "It's like learning to ride a bicycle. We learn when we are young, from our mothers. And we don't forget. Your women cannot do this, can they? When I was younger, we had to carry water like this for ten kilometers. But now I have a pipe and a faucet in my front yard."

And perhaps ten kilometers from her front yard, just over the horizon, people are living a lifestyle similar to that of suburban America.

South Africa is a land of contrasts. But America too has its diversity, and other countries can help us to explore how to work within this diversity and even to make it work for us.

While we don't have people totally excluded from the economy, we have many with whom its bounty is not shared. While we don't have schools without electricity, we have many without computers. Perhaps most important, we have students who are learning the dead-end mathematics of skill without concept. We have much to share with our neighbors in South Africa, and perhaps each of us has much to learn from the other.

Acknowledgment

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Reference

[1] See, for example, RALPH GASSER, Solving Nine Men's Morris, in *Games of No Chance: Combinatorial Games at MSRI* (Richard J. Nowakowsi, ed.), Cambridge Univ. Press, Cambridge, 1996.